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(54) **SYSTEM AND METHOD FOR DETERMINING A PUPILLARY RESPONSE TO A MULTIMEDIA DATA ELEMENT**

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CPC ***G06Q 30/0241*** (2013.01); ***G06F 17/3002*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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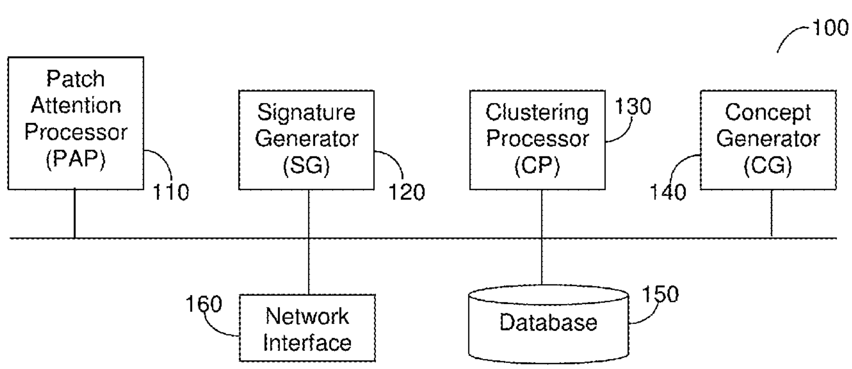
(57) **ABSTRACT**

A method for determining a pupillary response to a multimedia data element viewed through a user computing device. The method comprises receiving a first image of a viewer's pupil captured prior to display of the MMDE over the user computing device; receiving a second image of a viewer's pupil captured after the display of the MMDE over the user computing device; determining, using the first image and the second image, if the viewer's pupil has been dilated; querying a deep-content-classification system to find a match between at least one concept structure and the at least second image of the user's pupil; upon identification of at least one matching concept, receiving a first set of metadata related to the at least one matching concept structure; determining the viewer's attention to the displayed MMDE respective of the first set of metadata; associating the at least one MMDE with the determined user attention.

19 Claims, 9 Drawing Sheets



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8,868,619, which is a continuation of application No. 12/603,123, filed on Oct. 21, 2009, now Pat. No. 8,266,185, which is a continuation-in-part of application No. 12/084,150, filed on Apr. 7, 2009, now Pat. No. 8,655,801, and a continuation-in-part of application No. 12/195,863, filed on Aug. 21, 2008, now Pat. No. 8,326,775, which is a continuation-in-part of application No. 12/084,150, filed as application No. PCT/IL2006/001235 on Oct. 26, 2006, now Pat. No. 8,655,801, said application No. 12/603,123 is a continuation-in-part of application No. 12/348,888, filed on Jan. 5, 2009, which is a continuation-in-part of application No. 12/084,150, and a continuation-in-part of application No. 12/195,863, said application No. 12/603,123 is a continuation-in-part of application No. 12/538,495, filed on Aug. 10, 2009, now Pat. No. 8,312,031, which is a continuation-in-part of application No. 12/084,150, filed as application No. PCT/IL2006/001235 on Oct. 26, 2006, said application No. 12/538,495 is a continuation-in-part of application No. 12/195,863, and a continuation-in-part of application No. 12/348,888.

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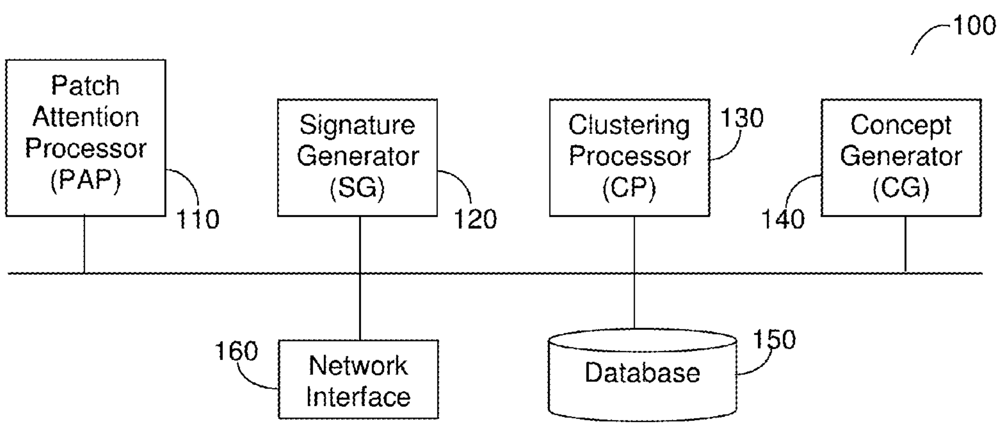
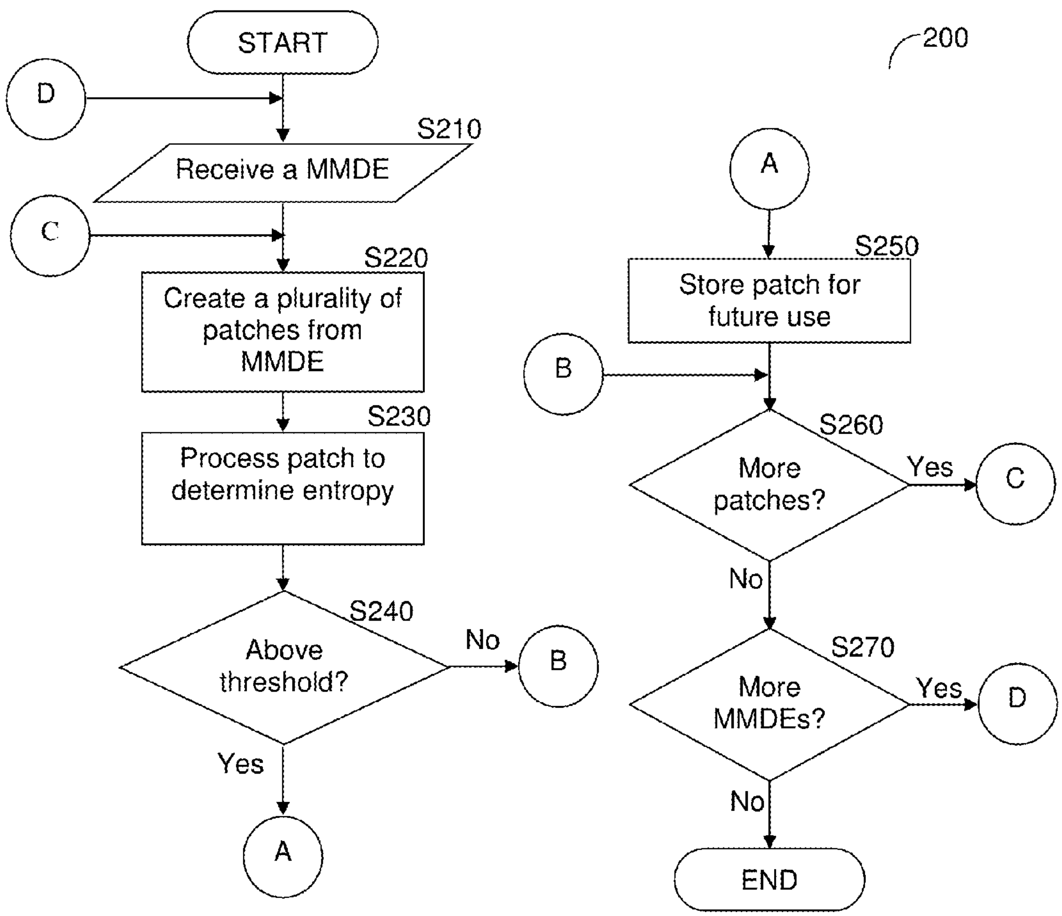

100
Patch Attention Processor (PAP)
110
Signature Generator (SG)
120
Clustering Processor (CP)
130
Concept Generator (CG)
140
160
Network Interface
Database
150

FIG. 1



200
START
D
S210
Receive a MMDE
C
S220
Create a plurality of patches from MMDE
S230
Process patch to determine entropy
S240
Above threshold?
No
B
Yes
A
A
S250
Store patch for future use
B
S260
More patches?
Yes
C
No
S270
More MMDEs?
Yes
D
No
END

FIG. 2

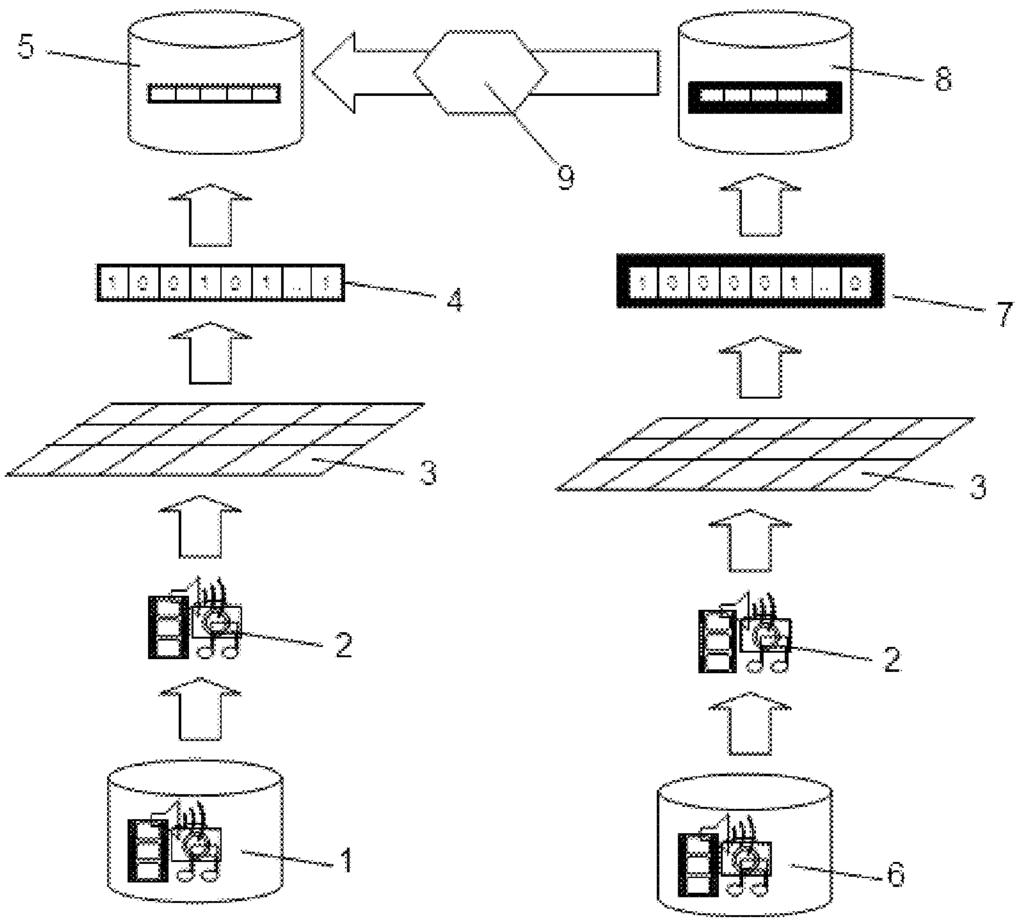


FIG. 3

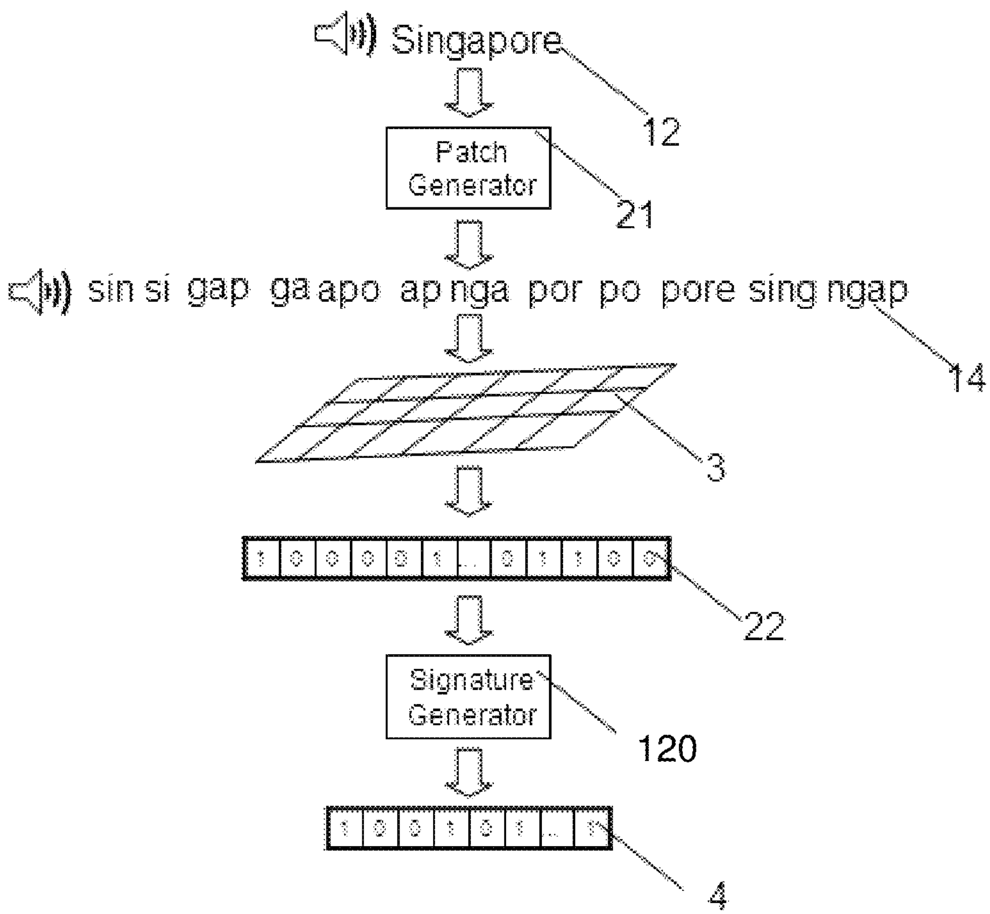

Singapore
12
Patch Generator
21
sin si gap ga apo ap nga por po pore sing ngap
14
3
22
Signature Generator
120
4

FIG. 4

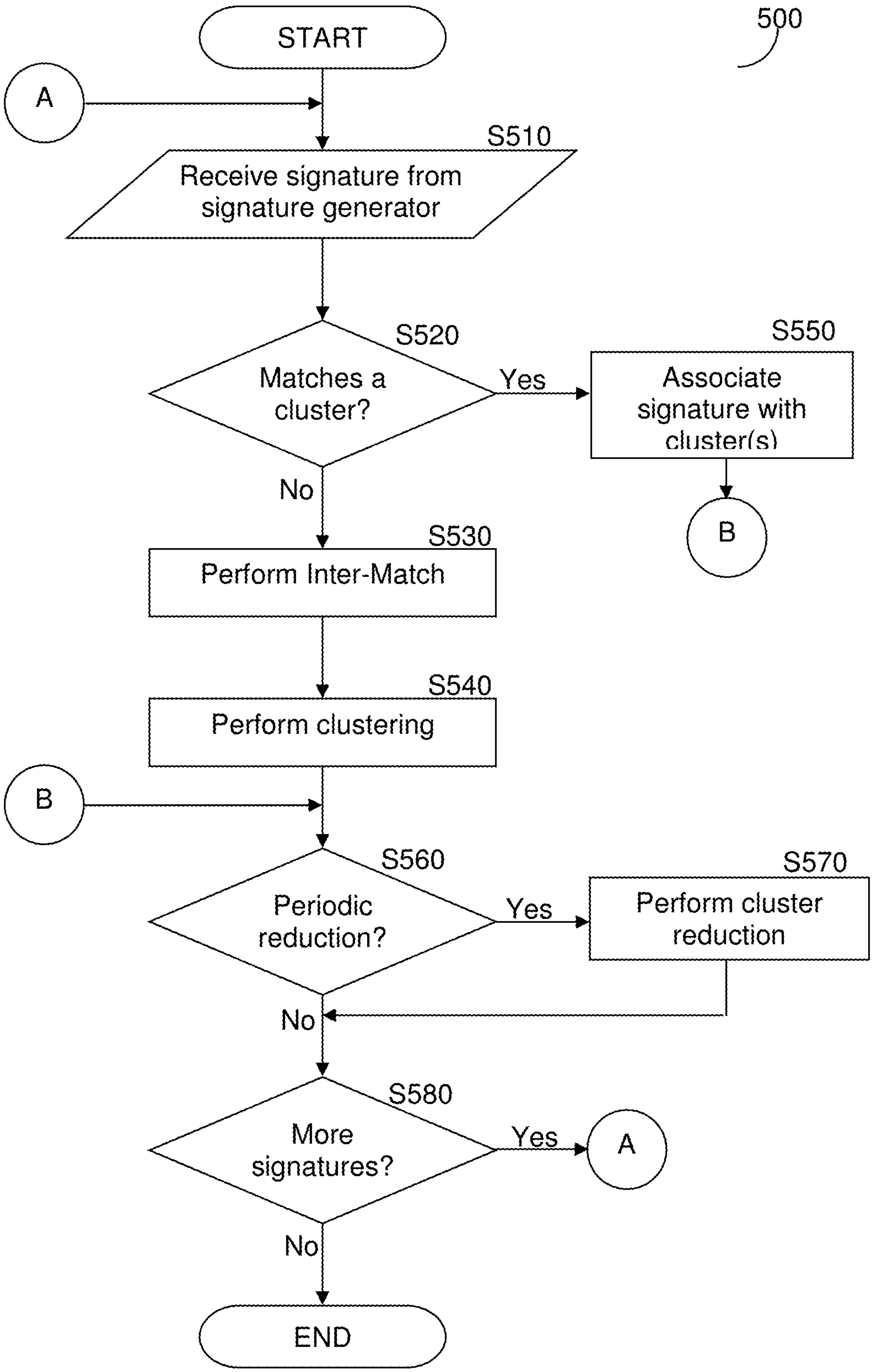

500
START
A
S510
Receive signature from signature generator
S520
Matches a cluster?
Yes
S550
Associate signature with cluster(s)
B
No
S530
Perform Inter-Match
S540
Perform clustering
B
S560
Periodic reduction?
Yes
S570
Perform cluster reduction
No
S580
More signatures?
Yes
A
No
END

FIG. 5

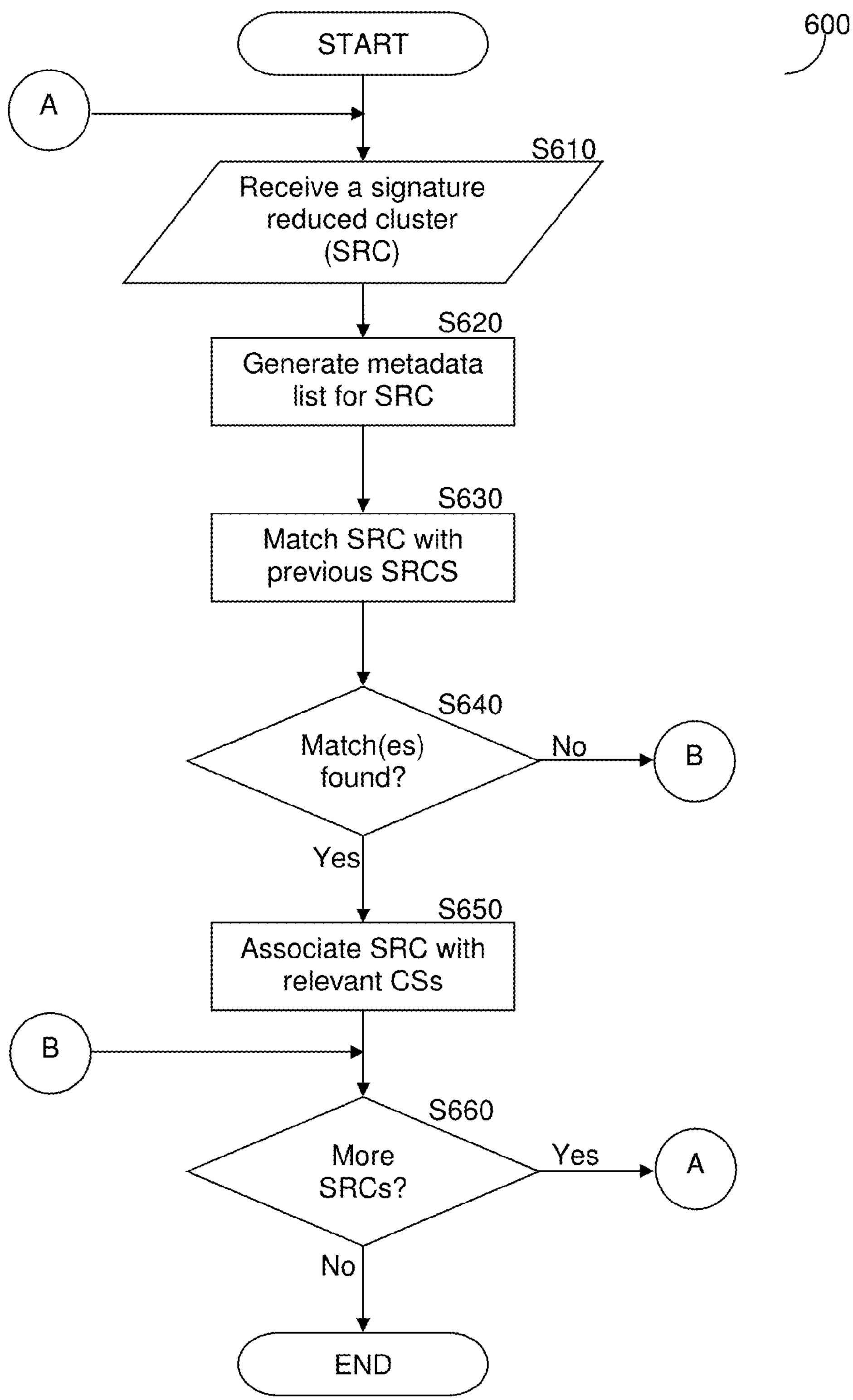

600
START
A
S610
Receive a signature reduced cluster (SRC)
S620
Generate metadata list for SRC
S630
Match SRC with previous SRCS
S640
Match(es) found?
No
B
Yes
S650
Associate SRC with relevant CSs
B
S660
More SRCs?
Yes
A
No
END

FIG. 6

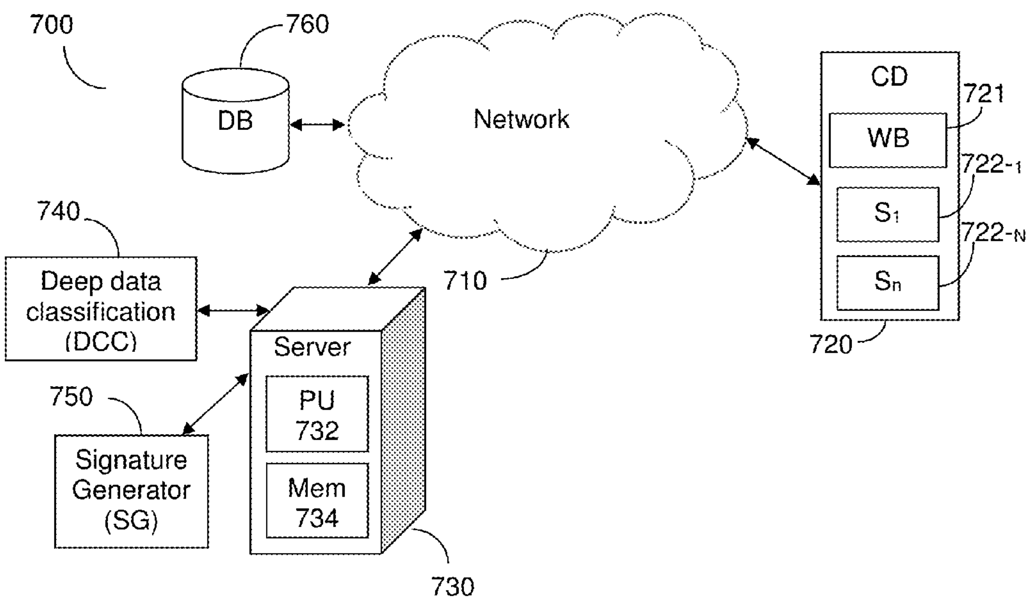
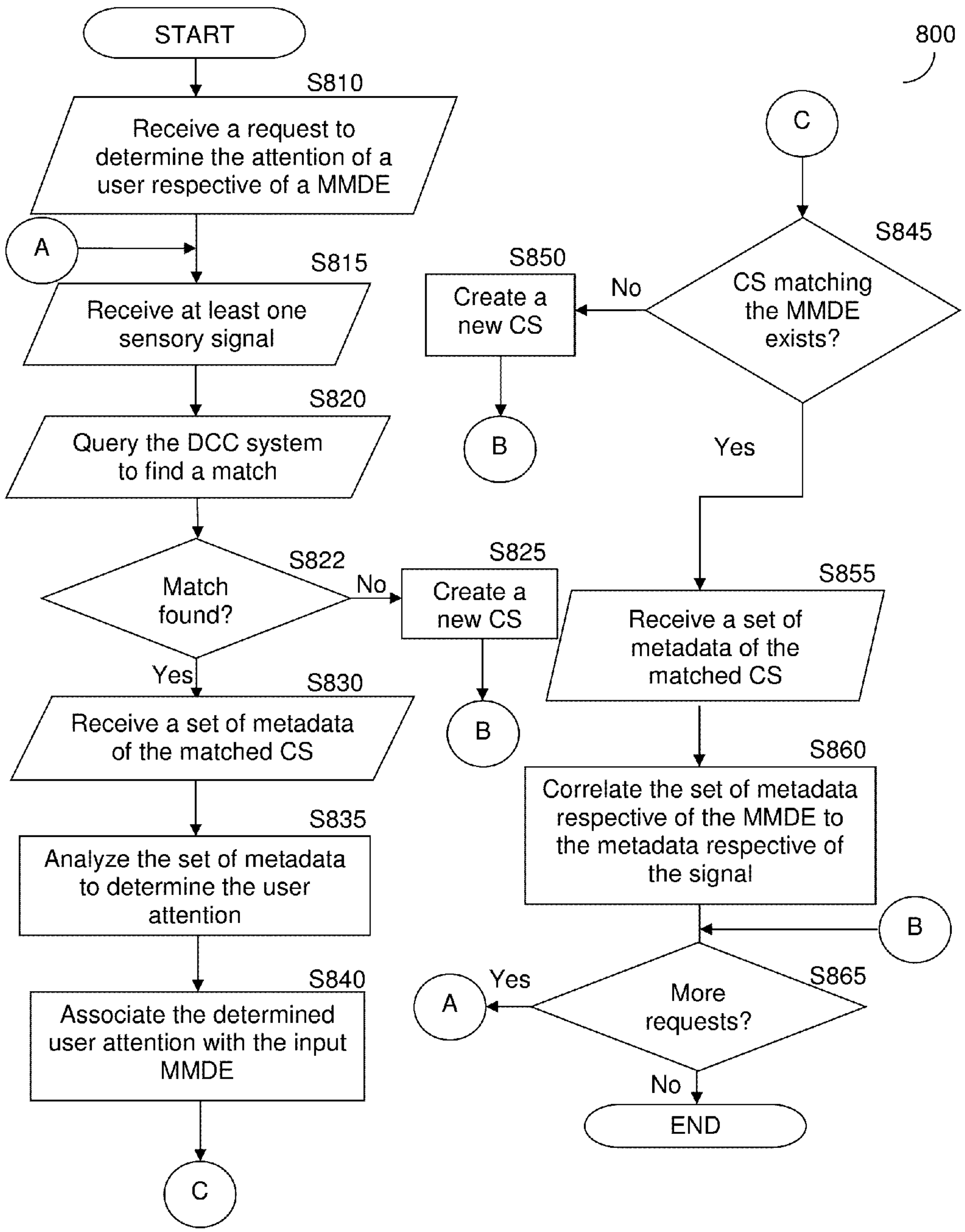

700
760
DB
Network
CD
721
WB
722-1
S1
722-N
Sn
720
710
740
Deep data classification (DCC)
Server
PU 732
Mem 734
750
Signature Generator (SG)
730

FIG. 7



800
START
S810
Receive a request to determine the attention of a user respective of a MMDE
A
S815
Receive at least one sensory signal
S820
Query the DCC system to find a match
S822
Match found?
No
S825
Create a new CS
B
Yes
S830
Receive a set of metadata of the matched CS
S835
Analyze the set of metadata to determine the user attention
S840
Associate the determined user attention with the input MMDE
C
C
S845
CS matching the MMDE exists?
No
S850
Create a new CS
B
Yes
S855
Receive a set of metadata of the matched CS
S860
Correlate the set of metadata respective of the MMDE to the metadata respective of the signal
B
S865
More requests?
Yes
A
No
END

FIG. 8

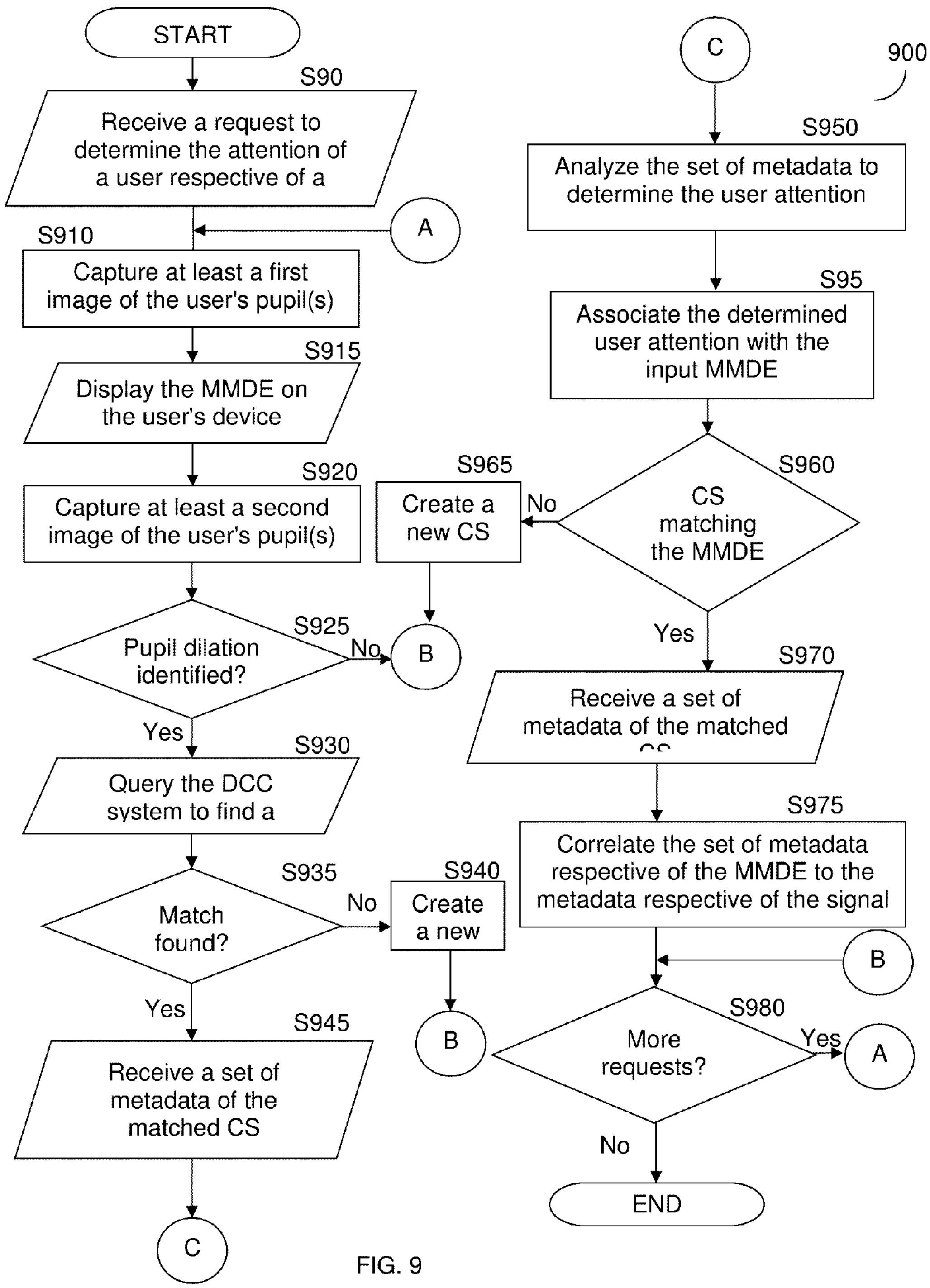

START
S90
Receive a request to determine the attention of a user respective of a
A
S910
Capture at least a first image of the user's pupil(s)
S915
Display the MMDE on the user's device
S920
Capture at least a second image of the user's pupil(s)
S925
Pupil dilation identified?
No
B
Yes
S930
Query the DCC system to find a
S935
Match found?
No
S940
Create a new
B
Yes
S945
Receive a set of metadata of the matched CS
C
C
900
S950
Analyze the set of metadata to determine the user attention
S95
Associate the determined user attention with the input MMDE
S965
Create a new CS
No
S960
CS matching the MMDE
Yes
S970
Receive a set of metadata of the matched CS
S975
Correlate the set of metadata respective of the MMDE to the metadata respective of the signal
B
S980
More requests?
Yes
A
No
END

FIG. 9

SYSTEM AND METHOD FOR DETERMINING A PUPILLARY RESPONSE TO A MULTIMEDIA DATA ELEMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Patent Application No. 61/939,289 filed on Feb. 13, 2014. This application is a continuation-in-part (CIP) of U.S. patent application Ser. No. 14/013,636 filed on Aug. 29, 2013, now pending. The Ser. No. 14/013,636 application is a CIP of patent application Ser. No. 13/602,858 filed on Sep. 4, 2012, now U.S. Pat. No. 8,868,619, which is a continuation of U.S. patent application Ser. No. 12/603,123, filed on Oct. 21, 2009, now U.S. Pat. No. 8,266,185. The Ser. No. 12/603,123 application is a continuation-in-part of:

(1) U.S. patent application Ser. No. 12/084,150 having a filing date of Apr. 7, 2009, now U.S. Pat. No. 8,655,801, which is the National Stage of International Application No. PCT/IL2006/001235, filed on Oct. 26, 2006, which claims foreign priority from Israeli Application No. 171577 filed on Oct. 26, 2005, and Israeli Application No. 173409 filed on Jan. 29, 2006;

(2) U.S. patent application Ser. No. 12/195,863, filed on Aug. 21, 2008, now U.S. Pat. No. 8,326,775, which claims priority under 35 USC 119 from Israeli Application No. 185414, filed on Aug. 21, 2007, and which is also a continuation-in-part of the above-referenced U.S. patent application Ser. No. 12/084,150;

(3) U.S. patent application Ser. No. 12/348,888, filed on Jan. 5, 2009, now pending, which is a CIP of the above-referenced U.S. patent application Ser. No. 12/084,150 U.S. patent application Ser. No. 12/195,863; and

(4) U.S. patent application Ser. No. 12/538,495, filed on Aug. 10, 2009, now U.S. Pat. No. 8,312,031, which is a CIP of the referenced-above U.S. patent application Ser. No. 12/084,150, the above-referenced U.S. patent application Ser. No. 12/195,863, and the above-referenced U.S. patent application Ser. No. 12/348,888.

All of the referenced-above applications and patents are herein incorporated by reference.

TECHNICAL FIELD

The present disclosure relates generally to the analysis of multimedia content, and more specifically to a system for determining a user attention to displayed multimedia content based on an analysis of sensory inputs performed by a deep-content-classification system.

BACKGROUND

The ubiquity of available access to information using the Internet and the worldwide web (WWW) has naturally drawn the focus of advertisers. As a result, the Internet has also become a popular medium for advertising, where commercials are included in webpages and the advertisers try to understand where to best place their advertisements in order to draw the attention of the users.

Targeting advertisements towards a specific demographic audience is a key component of successful advertising. Many solutions have been developed for gleaning demographic information about Internet users in order for advertisers to target an audience or user that would be more interested in their advertised product. With this aim, the demographic characteristics of the users that tend to visit

certain websites are determined in order to place ads targeted to certain demographics, such as age, gender, and the likes of users visiting the websites. Such targeted advertising enables marketing budgets to be spent more effectively.

However, it is common for a group of people with similar demographic characteristics to have different tastes, interests, and preferences. For example, when two persons having similar demographics view an advertisement for a seafood restaurant, one person may like, while the other person may dislike, the advertised product. That is, for a group of people from the same demographic group, each person in the group may have individual preferences not shared with other persons in the group. Furthermore, users' preferences may change over time, thus leaving the advertising content related to the user's previous preferences irrelevant. Therefore, solutions targeting advertisements discussed in the related art cannot provide a sufficiently accurate current indication as to whether or not the user likes or dislikes an advertised content.

Alternate solutions may employ pupillometry as a technique for measuring the interests of users in advertised content effectively target advertisements. As discussed in the related art, pupillometry is the measurement of the diameter of pupils in psychology. For example, "Eye-Opener: Why Do Pupils Dilate in Response to Emotional States" published on Dec. 7, 2012, by Joss Fong discusses pupillometry. The article, quoting Jagdish Sheth, a marketing professor at Emory University, describes pupillometry as a technique for measuring the consumers' responses to television commercials, and was eventually abandoned as a scientific way to establish whether it measured interest or anxiety was not found.

It would be therefore advantageous to provide a solution that would enable determination of the attention of a user to content, such as advertised content using modern pupillometry techniques.

SUMMARY

A summary of several example embodiments of the disclosure follows. This summary is provided for the convenience of the reader to provide a basic understanding of such embodiments and does not wholly define the breadth of the disclosure. This summary is not an extensive overview of all contemplated embodiments, and is intended to neither identify key or critical elements of all embodiments nor delineate the scope of any or all embodiments. Its sole purpose is to present some concepts of one or more embodiments in a simplified form as a prelude to the more detailed description that is presented later. For convenience, the term some embodiments may be used herein to refer to a single embodiment or multiple embodiments of the disclosure.

Certain embodiments include a method for determining a pupillary response to a multimedia data element (MMDE) viewed through a user computing device. The method comprises receiving a first image of a viewer's pupil captured prior to display of the MMDE over the user computing device; receiving a second image of a viewer's pupil captured after the display of the MMDE over the user computing device; determining, using the first image and the second image, if the viewer's pupil has been dilated; when identification identifying of a pupil dilation, querying a deep-content-classification (DCC) system to find a match between at least one concept structure and the at least second image of the user's pupil; upon identification of at least one matching concept, receiving a first set of metadata related to the at least one matching concept structure; determining the

viewer's attention to the displayed MMDE respective of the first set of metadata; and associating the at least one MMDE with the determined user attention.

Certain embodiments include a system for determining pupillary response to a multimedia data element (MMDE) viewed through a user computing device. The system comprises a processor; and a memory connected to the processor, the memory contains instructions that when executed by the processor, the system is configured to: receive a first image of a viewer's pupil captured prior to display of the MMDE over the user computing device; receive a second image of a viewer's pupil captured after the display of the MMDE over the user computing device; determine, using the first image and the second image, if the viewer's pupil has been dilated; when identifying of a pupil dilation, query a deep-content-classification (DCC) system to find a match between at least one concept structure and the at least second image of the user's pupil; upon identification of at least one matching concept, receive a first set of metadata related to the at least one matching concept structure; determine the viewer's attention to the displayed MMDE respective of the first set of metadata; and associate the at least one MMDE with the determined user attention.

BRIEF DESCRIPTION OF THE DRAWINGS

The subject matter that is disclosed herein is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other objects, features, and advantages of the disclosed embodiments will be apparent from the following detailed description taken in conjunction with the accompanying drawings.

FIG. **1** is a block diagram of a DCC system for creating concept structures utilized to carry some of the disclosed embodiments.

FIG. **2** is a flowchart illustrating the operation of the patch attention processor of the DCC system.

FIG. **3** is a block diagram depicting the basic flow of information in a large-scale video matching system.

FIG. **4** is a diagram showing the flow of patches generation, response vector generation, and signature generation in a large-scale speech-to-text system.

FIG. **5** is a flowchart illustrating the operation of the clustering processor of the DCC system shown in FIG. **1**.

FIG. **6** is a flowchart illustrating the operation of the concept generator of the DCC system shown in FIG. **1**.

FIG. **7** is a diagram of a network system utilized to describe certain disclosed embodiments.

FIG. **8** is a flowchart illustrating a method for determining attention of a user to displayed multimedia content according to an embodiment.

FIG. **9** is a flowchart illustrating a method for determining attention of a user to displayed multimedia content respective of the viewer's pupil dilation according to an embodiment.

DETAILED DESCRIPTION

The embodiments disclosed herein are only examples of the many possible advantageous uses and implementations of the innovative teachings presented herein. In general, statements made in the specification of the present application do not necessarily limit any of the various claimed embodiments. Moreover, some statements may apply to some inventive features but not to others. In general, unless otherwise indicated, singular elements may be in plural and vice versa with no loss of generality. In the drawings, like numerals refer to like parts through several views.

FIG. **1** shows an exemplary and non-limiting diagram of a DCC system **100** for creating concept structures. The DCC system includes a patch attention processor (PAP) **110**, a signature generator (SG) **120**, a clustering processor (CP) **130**, a concept generator (CG) **140**, a database (DB) **150**, and a network interface **160**.

The DCC system **100** is configured to receive multimedia data elements (MMDEs), for example from the Internet via the network interface **160**. The MMDEs include, but are not limited to, images, graphics, video streams, video clips, audio streams, audio clips, video frames, photographs, images of signals, combinations thereof, and portions thereof. The images of signals are images such as, but not limited to, medical signals, geophysical signals, subsonic signals, supersonic signals, electromagnetic signals, and infrared signals.

The MMDEs may be stored in a database (DB) **150** or kept in the DB **150** for future retrieval of the respective MMDE. Such a reference may be, but is not limited to, a universal resource locator (URL). Every MMDE in the DB **150**, or referenced therefrom, is then processed by a patch attention processor (PAP) **110** resulting in a plurality of patches that are of specific interest, or otherwise of higher interest than other patches. A more general pattern extraction, such as an attention processor (AP) may also be used in lieu of patches. The AP receives an MMDE that is partitioned into items; an item may be an extracted pattern or a patch, or any other applicable partition depending on the type of the MMDE. The functions of the PAP **110** are described herein below in more detail with respect to FIG. **2**.

The patches that are of higher interest are then used by the signature generator (SG) **120** to generate signatures respective of the patch. The operation of the signature generator (SG) **120** is described in more detail herein below. The clustering processor (CP) **130** is configured to initiate a process of inter-matching of the signatures once it determines that there are a number of patches that are above a predefined threshold. The threshold may be defined to be large enough to enable proper and meaningful clustering. With a plurality of clusters a process of clustering reduction takes place so as to extract the most useful data about the cluster and keep it at an optimal size to produce meaningful results. The process of cluster reduction is continuous. When new signatures are provided after the initial phase of the operation of the CP **130**, the new signatures may be immediately checked against the reduced clusters to save on the operation of the CP **130**. A more detailed description of the operation of the CP **130** is provided herein below with respect to FIG. **5**.

The concept generator (CG) **140** is configured to create concept structures from the reduced clusters provided by the CP **130**. Each concept structure comprises a plurality of metadata associated with the reduced clusters. The result is a compact representation of a concept that can now be easily compared against a MMDE to determine if the received MMDE matches a concept structure stored, for example in the DB **150**, by the CG **140**. This can be done, for example and without limitation, by providing a query to the DCC system **100** for finding a match between a concept structure and a MMDE. A more detailed description of the operation of the CG **140** is provided herein below.

It should be appreciated that the DCC system **100** can generate a number of concept structures significantly smaller than the number of MMDEs. For example, if one billion

(10^9) MMDEs need to be checked for a match against another one billion MMDEs, typically the result is that no less than $10^9 \times 10^9 = 10^{18}$ matches have to take place, a daunting undertaking. The DCC system **100** would typically have around 10 million concept structures or less, and therefore at most only $2 \times 10^6 \times 10^9 = 2 \times 10^{15}$ comparisons need to take place, a mere 0.2% of the number of matches that have had to be made by other solutions. As the number of concept structures grows significantly slower than the number of MMDEs, the advantages of the DCC system **100** would be apparent to one with ordinary skill in the art.

The operation of the PAP **110** will now be provided in greater detail with respect to an image as the MMDE. However, this should not be understood as to limit the scope of the disclosed embodiments; other types of MMDEs are specifically included herein and may be handled by the PAP **110**.

FIG. **2** depicts an exemplary and non-limiting flowchart **200** of the operation of the PAP **110**. In S**210**, a MMDE is received from a source for such MMDEs. Such a source may be a system that feeds the DCC system **100** with MMDEs or other sources for MMDEs, for example the world-wide-web (WWW). In S**220**, a plurality of patches is created from the MMDE. A patch of an image is defined by, for example, its size, scale, location, and orientation. A patch may be, for example and without limitation, a portion of an image of a size 20 pixels by 20 pixels of an image that is 1,000 pixels by 500 pixels. In the case of audio, a patch may be a segment of audio 0.5 seconds in length from a 5 minute audio clip. In S**230**, a patch not previously checked is processed to determine its entropy. The entropy is a measure of the amount of interesting information that may be present in the patch. For example, a continuous color of the patch has little interest while sharp edges, corners, or borders will result in higher entropy representing a lot of interesting information. The plurality of statistically independent cores, the operation of which is discussed in more detailed herein below with respect to FIGS. **3** and **4**, is used to determine the level-of-interest of the image and a process of voting takes place to determine whether the patch is of interest or not.

In S**240**, it is checked whether the entropy of the patch was determined to be above a predefined threshold, and if so execution continues with S**250**; otherwise, execution continues with S**260**. In S**250**, the patch having entropy above the threshold is stored for future use by the SG **120** in, for example, DB **150**. In S**260**, it is checked whether there are more patches of the MMDE to be checked, and if so execution continues with S**220**; otherwise execution continues with S**270**. In S**270**, it is checked whether there are additional MMDEs, and if so execution continues with S**210**; otherwise, execution terminates. It would be appreciated by those of skill in the art that this process reduces the information that must be handled by the DCC system **100** by focusing on areas of interest, i.e. patches of high entropy, in the MMDEs rather than areas that are less meaningful for the formation of a concept structure.

A high-level description of the process for large scale video matching performed by the Matching System is depicted in FIG. **3**. Video content segments **2** from a Master DB **6** and a Target DB **1** are processed in parallel by a large number of independent computational Cores **3** that constitute the Architecture. Further details on the computational Cores generation are provided below. The independent Cores **3** generate a database of Robust Signatures and Signatures **4** for Target content-segments **5** and a database of Robust Signatures and Signatures **7** for Master content-segments **8**. An exemplary and non-limiting process of signature generation for an audio component is shown in detail in FIG. **4**. Referring back to FIG. **3**, at the final step, Target Robust Signatures and/or Signatures are effectively matched, by a matching algorithm **9**, to Master Robust Signatures and/or Signatures database to find all matches between the two databases.

A brief description of the operation of the SG **120** is therefore provided, this time with respect to a MMDE which is a sound clip. However, this should not be understood as to limit the scope of the disclosure and other types of MMDEs are specifically included herein and may be handled by SG **120**. To demonstrate an example of signature generation process, it is assumed, merely for the sake of simplicity and without limitation on the generality of the disclosed embodiments, that the signatures are based on a single frame, leading to certain simplification of the computational core's generation. The Matching System shown in FIG. **3** is extensible for signatures generation capturing the dynamics in-between the frames and the information of the frame's patches.

The signatures generation process will be described with reference to FIG. **4**. The first step in the process of signatures generation from a given speech-segment is to break-down the speech-segment to K patches **14** of random length P and random position within the speech segment **12**. The break-down is performed by the patch generator component **21**. The value of K is determined based on optimization, considering the tradeoff between accuracy rate and the number of fast matches required in the flow process of the Matching System. In the next step, all the K patches are injected in parallel to all L computational Cores **3** to generate K response vectors **22**. The vectors **22** are fed into the SG **120** to produce a Signatures and Robust Signatures **4**.

In order to generate Robust Signatures, i.e., Signatures that are robust to additive noise L (where L is an integer equal to or greater than 1) computational cores are utilized in the Matching System. A frame i is injected into all the Cores. The computational cores **3** generate two binary response vectors: $\vec{S}$ which is a Signature vector, and $\overrightarrow{RS}$ which is a Robust Signature vector.

For generation of signatures robust to additive noise, such as White-Gaussian-Noise, scratch, etc., but not robust to distortions, such as crop, shift and rotation, etc., a core $C_i=\{n_i\}$ ($1 \le i \le L$) may consist of a single leaky integrate-to-threshold unit (LTU) node or more nodes. The node n_i equations are:

$$V_i = \sum_j w_{ij} k_j$$

$n_i = \Pi(Vi - Th_x)$; Π is a Heaviside step function; w_{ij} is a coupling node unit (CNU) between node i and image component j (for example, grayscale value of a certain pixel j); k_j is an image component j (for example, grayscale value of a certain pixel j); Th_x is a constant Threshold value, where x is 'S' for Signature and 'RS' for Robust Signature; and V_i is a Coupling Node Value.

The Threshold values Th_x are set differently for Signature generation and for Robust Signature generation. For example, for a certain distribution of V_i values (for the set of nodes), the thresholds for Signature (Th_S) and Robust Signature (Th_{RS}) are set apart, after optimization, according to at least one or more of the following criteria:

I: For: $V_i > Th_{RS}$

$1-p(V>Th_S)-1-(1-\epsilon)^l<<1$

i.e., given that l nodes (cores) constitute a Robust Signature of a certain image l, the probability that not all of these l nodes will belong to the Signature of same, but noisy image, $\tilde{I}$ is sufficiently low (according to a system's specified accuracy).

II: $p(V_i>Th_{RS})\approx l/L$

i.e., approximately l out of the total L nodes can be found to generate Robust Signature according to the above definition.

III: Both Robust Signature and Signature are generated for certain frame i.

It should be understood that the creation of a signature is a unidirectional compression where the characteristics of the compressed data are maintained but the compressed data cannot be reconstructed. Therefore, a signature can be used for the purpose of comparison to another signature without the need of comparison of the original data. The detailed description of the Signature generation can be found U.S. Pat. Nos. 8,326,775 and 8,312,031, assigned to common assignee, which are hereby incorporated by reference for all the useful information they contain.

Computational Core generation is a process of definition, selection and tuning of the Architecture parameters for a certain realization in a specific system and application. The process is based on several design considerations, such as: (a) The Cores should be designed so as to obtain maximal independence, i.e. the projection from a signal space should generate a maximal pair-wise distance between any two Cores' projections into a high-dimensional space; (b) The Cores should be optimally designed for the type of signals, i.e. the Cores should be maximally sensitive to the spatio-temporal structure of the injected signal, for example, and in particular, sensitive to local correlations in time and space. Thus, in some cases a Core represents a dynamic system, such as in state space, phase space, edge of chaos, etc., which is uniquely used herein to exploit their maximal computational power; and (c) The Cores should be optimally designed with regard to invariance to a set of signal distortions, of interest in relevant applications. Detailed description of the Computational Core generation, the computational architecture, and the process for configuring such cores is discussed in more detail in U.S. Pat. No. 8,655,801, assigned to the common assignee.

Hence, signatures are generated by the SG **120** responsive of patches received either from the PAP **110**, or retrieved from the DB **150**, as discussed hereinabove. It should be noted that other ways for generating signatures may also be used for the purpose of the DCC system **100**. Furthermore, as noted above, the array of computational cores may be used by the PAP **110** for the purpose of determining if a patch has an entropy level that is of interest for signature generation according to the principles of the disclosed embodiments. The generated signatures are stored, for example, in the DB **150**, with reference to the MMDE and the patch for which it was generated, thereby enabling back annotation as may be necessary.

Portions of the CP **130** have been discussed in detail in the U.S. Pat. No. 8,386,400, entitled "Unsupervised Clustering of Multimedia Data Using a Large-Scale Matching System", assigned to common assignee (the '400 patent), and which is hereby incorporated for all that it contains. In accordance with an embodiment an inter-match process and clustering thereof is utilized. The process can be performed on signatures provided by the SG **120**. It should be noted though that this inter-matching and clustering process is merely an example for the operation of the CP **130** and other inter-matching and/or clustering processes may be used for the purpose of the disclosed embodiments.

Following is a brief description of the inter-match and clustering process. The unsupervised clustering process maps a certain content-universe onto a hierarchical structure of clusters. The content-elements of the content-universe are mapped to signatures, when applicable. The signatures of all the content-elements are matched to each other, and consequently generate the inter-match matrix. The described clustering process leads to a set of clusters. Each cluster is represented by a small/compressed number of signatures, for example signatures generated by the SG **120** as further explained hereinabove, which can be increased by variants. This results in a highly compressed representation of the content-universe. A connection graph between the multimedia data elements of a cluster may be stored. The graph can then be used to assist a user searching for data to move along the graph in the search of a desired multimedia data element.

In another embodiment, upon determination of a cluster, a signature for the whole cluster may be generated based on the signatures of the multimedia data elements that belong to the cluster. It should be appreciated that a Bloom filter may be used to reach such signatures. Furthermore, as the signatures are correlated to some extent, the hash functions of the Bloom filter may be replaced by simpler pattern detectors, with the Bloom filter being the upper limit.

While signatures are used here as the basic data elements, it should be realized that other data elements may be clustered using the techniques discussed above. For example, a system generating data items may be used, where the data items generated may be clustered according to the disclosed principles. Such data items may be, without limitation, MMDEs. The clustering process may be performed by dedicated hardware or by using a computing device having storage to store the data items generated by the system and then perform the process described herein above. Then the clusters can be stored in memory for use as may be deemed necessary.

The CP **130** is further configured to use an engine designed to reduce the number of signatures used in a structure, in a sense extracting only the most meaningful signatures that identify the cluster uniquely. This can be done by testing a removal of a signature from a cluster and checking if the MMDEs associated with the cluster still are capable of being recognized by the cluster through signature matching.

The process of signature extraction is ongoing as the DCC system **100** operates. It should be noted that after initialization, and upon signature generation by the SG **120** of a MMDE, the MMDE's respective signature is first checked against the clusters to see if there is a match and if so, it may not be necessary to add the signature to the cluster or clusters but rather simply associate the MMDE with the identified cluster or clusters. However, in some cases where additional refinement of the concept structure is possible, the signature may be added, or at times even replace one or more of the existing signatures in the reduced cluster. If no match is found then the process of inter-matching and clustering may take place.

FIG. **5** depicts an exemplary and non-limiting flowchart **500** of the operation of the CP **130**. In S**510**, a signature of a MMDE is received, for example from the SG **120**. In S**520**, it is checked whether the signature matches one or more existing clusters and if so execution continues with S**550**;

otherwise, execution continues with **S530**. In **S530**, an inter-match between a plurality of signatures previously received by the DCC system **100** is performed, for example in accordance with the principles of the '400 patent. As may be necessary, the DB **150** may be used to store results or intermediate results, however other memory elements may be used. In **S540**, a clustering process takes place, for example in accordance with the principles of the '400 patent. As may be necessary, the DB **150** may be used to store results or intermediate results, however other memory elements may be used.

In **S550**, the signature identified to match one or more clusters is associated with the existing cluster(s). In **S560**, it is checked whether a periodic cluster reduction is to be performed, and if so execution continues with **S570**; otherwise, execution continues with **S580**.

In **S570**, the cluster reduction process is performed. Specifically, the purpose of the operation is to ensure that in the cluster there remains the minimal number of signatures that still identify all of the MMDEs that are associated with the signature reduced cluster (SRC). This can be performed, for example, by attempting to match the signatures of each of the MMDEs associated with the SRC having one or more signatures removed therefrom. The process of cluster reduction for the purpose of generating SRCs may be performed in parallel and independently of the process described herein above. In such a case, after either **S560** or **S570** the operation of **S580** takes place.

In **S580**, it is checked whether there are additional signatures to be processed and if so execution continues with **S510**; otherwise, execution terminates. SRCs may be stored in a memory, such as DB **150**, for the purpose of being used by other elements comprising the DCC system **100**.

The CG **140** performs two tasks: it associates metadata to the SRCs provided by the CP **130** and it associates between similar clusters based on commonality of metadata. Exemplary and non-limiting methods for associating metadata with MMDEs is described in U.S. patent application Ser. No. 12/348,888, entitled "Methods for Identifying Relevant Metadata for Multimedia Data of a Large-Scale Matching System", filed on Jan. 5, 2009, assigned to common assignee (the "'888 application"), which is hereby incorporated for all that it contains. One embodiment of the '888 application includes a method for identifying and associating metadata to input MMDEs. The method comprises comparing an input first MMDE to at least a second MMDE; collecting metadata of at least the second MMDE when a match is found between the first MMDE and at least the second MMDE; associating at least a subset of the collected metadata to the first MMDE; and storing the first MMDE and the associated metadata in a storage.

Another embodiment of the '888 application includes a system for collecting metadata for a first MMDE. The system comprises a plurality of computational cores enabled to receive the first MMDE, each core having properties to be statistically independent of each other core, each generate responsive to the first MMDE a first signature element and a second signature element, the first signature element being a robust signature; a storage unit for storing at least a second MMDE, metadata associated with the second MMDE, and at least one of a first signature and a second signature associated with the second MMDE, the first signature being a robust signature; and a comparison unit for comparing signatures of MMDEs coupled to the plurality of computational cores and further coupled to the storage unit for the purpose of determining matches between multimedia data elements; wherein responsive to receiving the first MMDE the plurality of computational cores generate a respective first signature of said first MMDE and/or a second signature of said first MMDE, for the purpose of determining a match with at least a second MMDE stored in the storage and associating metadata associated with the at least second MMDE with the first MMDE.

Similar processes to match metadata with a MMDE or signatures thereof may be used. Accordingly, each SRC is associated with metadata which is the combination of the metadata associated with each of the signatures that are included in the respective SRC, preferably without repetition of metadata. A plurality of SRCs having metadata may now be associated to each other based on the metadata and/or partial match of signatures. For example, and without limitation, if the metadata of a first SRC and the metadata of a second SRC overlap more than a predetermined threshold level, for example 50% of the metadata match, they may be considered associated clusters that form a concept structure. Similarly, a second threshold level can be used to determine if there is an association between two SRCs where at least a number of signatures above the second threshold are identified as a match with another SRC. As a practical example, one may want to consider the concept of Abraham Lincoln where images of the late President, and features thereof, appear in a large variety of photographs, drawings, paintings, sculptures, and more and are associated as a concept structure of the concept "Abraham Lincoln". Each concept structure may be then stored in memory, for example the DB **150**, for further use.

FIG. **6** shows an exemplary and non-limiting flowchart **600** of the operation of the CG **140**. In **S610**, a SRC is received from either the CP **130** or by accessing memory, for example, the DB **150**. In **S620**, metadata are generated for the signatures of the SRC, for example in accordance with the principles described hereinabove. A list of the metadata is created for the SRC preferably with no metadata duplication. In one embodiment the commonality of metadata is used to signify the strength of the metadata with respect to a signature and/or the SRC, i.e., a higher number of metadata repetitions is of more importance to the SRC than a lower number of repetitions. Furthermore, in one embodiment a threshold may be used to remove those metadata that have a significantly low rate of repetition as not being representative of the SRC.

In **S630**, the SRC is matched to previously generated SRCs to attempt to find various matches as described, for example, hereinabove in more detail. In **S640**, it is checked if at least one match was found and if so, execution continues with **S650**; otherwise, execution continues with **S660**. In **S650**, the SRC is associated with one or more of the concept structures to which the SRC has been shown to match. In **S660**, it is checked whether additional SRCs are to be received and if so execution continues with **S610**; otherwise, execution terminates.

A person skilled in the art would now appreciate the advantages of the DCC system **100** and methods thereof. The DCC system **100** is configured to create automatically and in an unsupervised fashion concept structures of a wide variety of MMDEs. When checking a new MMDE, it may be checked against the concept structures stored, for example, in the DB **150** and upon detection of a match provide the concept information about the MMDE. When the number of concept structures is significantly lower than the number of MMDEs, the solution is cost effective and scalable for the purpose of identification of content of a MMDE.

FIG. **7** shows an exemplary and non-limiting schematic diagram of a network system **700** utilized to describe various disclosed embodiments. A network **710** is used as a means for communication between different elements of the system **700**. The network **710** may be the Internet, the world-wide-web (WWW), a local area network (LAN), a wide area network (WAN), a metro area network (MAN), and the like.

At least one computing device **720** is connected to the network **710**. The computing device **720** includes at least a program to access the Internet or any other network, such as, but not limited to, a web browser **721**. The computing device **720** also includes one or more physical sensors **722-1** through **722-***n* (collectively referred hereinafter as sensors **722** or individually as a sensor **722**, merely for simplicity purposes) configured to capture sensory information. In a preferred embodiment, the sensory information is captured with respect to a MMDE displayed over the web browser **721**. Each one of the sensors **722** may be, for example, but not limited to, a camera, a web camera, a microphone, a Global Positioning System (GPS), an image analyzer, a speech recognizer, and the like.

The computing device **720** may be, for example, a personal computer (PC), a personal digital assistant (PDA), a mobile phone, a smartphone, a tablet computer, a wearable computing device, and other kinds of wired and mobile appliances, equipped with browsing, viewing, listening, filtering, and managing capabilities.

Also connected to the network **710** is a server **730** configured to perform the process of determining the user attention to the displayed content. To this end, the server **730** is connected to a DCC system **740** and a signature generator **750**. The DCC system **740** is configured and operates as the DCC system **100** discussed in detail above. The signature generator **750** is configured and operates as the SG **120**. In certain configurations, the SG of the DCC system **740** is utilized as the signature generator **750**. The DCC system **740** and signature generator **750** may be connected through the server **730** to the network **710** or through a direct connection.

In certain configurations, the DCC system **740** and signature generator **750** may be embedded in the server **730**. It should be noted that the server **730** typically comprises a processing unit **732** and a memory **734**. The processing unit **732** is coupled to the memory **734**, which is configured to contain instructions that can be executed by the processing unit. The server **730** also includes a network interface (not shown) to the network **710**.

In an embodiment, the processing unit **732** may comprise, or be a component of, a larger processing unit implemented with one or more processors. The one or more processors may be implemented with any combination of general-purpose microprocessors, microcontrollers, digital signal processors (DSPs), field programmable gate array (FPGAs), programmable logic devices (PLDs), controllers, state machines, gated logic, discrete hardware components, dedicated hardware finite state machines, or any other suitable entities that can perform calculations or other manipulations of information.

The processing unit **732** may also include machine-readable media for storing software. Software shall be construed broadly to mean any type of instructions, whether referred to as software, firmware, middleware, microcode, hardware description language, or otherwise. Instructions may include code (e.g., in source code format, binary code format, executable code format, or any other suitable format of code). The instructions, when executed by the processing unit, cause the processing unit to perform the various functions described herein.

According to the embodiments disclosed herein, a user visits a webpage using a web browser **721**. When the webpage is uploaded on the user's web browser **721**, a request is sent to the server **730** to analyze an identified multimedia content element (the "input MMDE") contained in the webpage. The request to analyze the input MMDE can be generated and sent by a script executed in the webpage, and/or an agent (e.g., plug-in) installed in the web browser **720**. The request may include the actual webpage with an identifier of the input MMDE to be processed, a URL of the webpage with an identifier of the input MMDE, or a URL to the element to be analyzed.

In one embodiment, the identification of the input MMDE(s) to be processed is provided by an ad-serving system (not shown). The input MMDE processed by the server **730** may be an image, a graphic, a video stream, a video clip, an audio stream, an audio clip, a video frame, a photograph, and an image of signals (e.g., spectrograms, phasograms, scalograms, etc.), and/or combinations thereof and portions thereof. In one embodiment, the MMDE is a web advertisement.

The request sent from the web browser **721** may also include one or more sensory signals captured by the one or more sensors **722**. The sensory signals may be, for example, an audio signal, a video signal, coordinates, a sonography signal, and so on. In one embodiment, the request may include additional parameters, such as an IP address of the computing device, time, date, a browser type, and so on. Such parameters may be used in determining the user's attention and/or to provide supplemental information for the association of the input MMDE and the determined user's attention.

According to the one embodiment, the DCC system **740** is primarily utilized to match between the input MMDE and one more concept structures (or concepts) to determine which the MMDE represents, for example, based on the metadata associated with the matched concept(s). The MMDE may be a sensory signal captured by a sensor **722** and/or multimedia content displayed over a web browser.

Specifically, according to the disclosed embodiments, the web browser **721** is configured to upload webpages or references (e.g., URLs) to the webpages that contain at least one multimedia data element (MMDE). The server **730** is configured to determine the attention of the user of the computing device **720** with respect to the input MMDE displayed in each webpage.

With this aim, the received sensory signal is processed and analyzed for the purpose of matching the sensory signal to concept structures generated and maintained by the DCC system **740**. Such a match requires generating at least one signature to the sensory signal and matching the generated signature(s) against the concept structures. The signature for the sensory signal may be generated by means of the signature generator **750**. The matching between signatures and concept structures is performed as discussed above.

The metadata of each matching concept structure is further analyzed to determine the attention of the user to the MMDE displayed to the user. As discussed above, the concept is a collection of signatures representing MMDEs and metadata describing the concept. As a non-limiting example, a 'smiley face' concept is a signature reduced cluster of signatures describing multimedia elements related to a smiley face (e.g., to people and cartoons representing smiles and/or happy faces), as well as a set of metadata representing proving textual representation (e.g., happy, amazed, amused, etc.) of the concept.

As a non-limiting example, if the sensory signal is an image of the user having a smile on his/her face, then the sensory signal (or its respective signature) would likely match the 'smiley face' concept. An analysis of the metadata would determine the result that the user attention was positive to the MMDE contained in the webpage sent along the sensory signal.

In one embodiment, if the sensory signal matches more than one concept structure and/or multiple sensory signals are received, the respective metadata of the matched concepts are correlated and then analyzed to determine the user attention. The determined attention is associated with the input MMDE.

In one embodiment, the server **730** is also configured to match the input MMDE to one or more concept structures. The metadata of concept structures matching the webpage's MMDE is correlated to the determined user's attention (or the metadata representing the same). This embodiment provides a general idea on what a particular user would like or dislike. As a non-limiting example, the 'Superman concept' is a signature reduced cluster of signatures describing multimedia elements related to, e.g., to the Superman comic and a set of metadata representing proving textual representation of the Superman concept structure. If the input MMDE is matched to the Superman concept and the user's attention determined with respect to the input MMDE is positive, then the outcome of such correlation would be that the user likes comics in general, and Superman comics in particular. It should be appreciated that using signatures and concept structures as part of the analysis ensures more accurate recognition of the users attention to displayed content, and thus to provide future content (e.g., online ads) that would better fit the user's interest.

In one embodiment, correlation between matching concept structures is performed. This can be achieved by identifying a ratio between signatures' sizes, a spatial location of each signature, and so on using the probabilistic models. In one embodiment, the system **700** further comprises a database, for example the DB **760**, which is configured to store the input MMDEs together with the respective user's attention, and any other supplemental information as discussed above.

FIG. **8** is a non-limiting and exemplary flowchart **800** describing a method for determining a viewer attention to the displayed multimedia content according to one embodiment. In S**810**, a request is received to determine the attention of a viewer respective of a MMDE included in the webpage that the viewer (or user) visits over the web browser **721**. As noted above, the request may include the actual webpage with an identifier of the input MMDE to be processed, a URL of the webpage with an identifier of the input MMDE, or a URL to the element to be analyzed. The request may also include additional parameters, such as an IP address of the computing device, time, date, a browser type, and so on.

In S**815**, at least one sensory signal captured by at least one sensor **722** while the viewer viewed the webpage is received. The sensory signal may be, for example, an audio signal, a video signal, coordinates, a sonography signal, and so on. It should be appreciated that the sensory signals are also multimedia signals that can be processed by the DCC system and the signature generator.

In S**820**, the DCC system (e.g., system **740**) is queried to find a match between at least one concept structure (CS) and the received sensory signal. In S**822**, it is checked if such a match is found, and if so execution continues with S**830**; otherwise, execution continues with S**825**. In S**825**, if a match was not found, the sensory signal is input to the DCC system to create a new concept structure as discussed above and execution continues with S**865**. In S**830**, a set of metadata of the matching concept structure is returned.

In S**835**, the set of returned metadata is analyzed to determine the viewer's attention. As noted above, the metadata provides textual representation of the contents of the concept structure, thus the analysis of the textual representation also determines if at least the viewer's attention with respect to the input MMDE was positive (like), negative (dislike), or natural. Examples for the operation of S**835** are provided above with respect to FIG. **7**.

In S**840**, the determined viewer's attention is associated with the input MMDE and such association is saved optionally together with the supplemental information in the DB **760**.

Optionally, in S**845**, a check is made to determine if the input MMDE matches at least one concept structure. The matching between an input MMDE and a concept structure is performed by querying the DCC system. If such a match is found, execution continues with S**855** where a set of metadata of the matched concept structure is returned. If a match was not found, execution continues with S**850** where the input MMDE is provided to the DCC system to create a new concept structure as discussed above.

In S**860**, the metadata returned with respect to the input MMDE is correlated with the metadata returned with respect to the sensory signal and/or the determined attention. The correlation outcome provides a general idea about the preferences, tastes, and/or interests of the viewer. In an embodiment, the correlation outcome may be saved, in a database, with an identifier identifying the viewer (e.g., a user name) and/or an identifier identifying the computing device (e.g., an IP address). In S**865**, it is checked whether there are additional requests and if so, execution continues with S**815**, otherwise, execution terminates.

Following is another non-limiting example for the operation of the embodiments discussed above. A request to analyze an image shown in a webpage is received. The webpage is viewed by a viewer. In response, at least one signature is generated by the signature generator **750** respective of a kitten shown in the image. In addition, a web camera captures a picture of a viewer. Such a picture is considered as the sensory signal, and as such a signature is generated by the signature generator **750** respective of a facial expression shown in the picture. The signature generated respective of the picture is matched to a concept structure representing positive facial expressions. Respective of the match, the viewer's attention is determined to be positive. As a result, the user positively responds to multimedia content that comprises a kitten, thus the user attention to such multimedia content is determined to be of high interest to the user.

FIG. **9** is a non-limiting and exemplary flowchart **900** describing a method for determining attention of a viewer to displayed multimedia content respective of the viewer's pupil dilation in accordance with one embodiment.

In S**905**, a request is received to determine the attention of a viewer respective of a MMDE. The MMDE may be included in the webpage that a user (or viewer) visits over the web-browser **721**, captured through a wearable computing device, for example, a head mounted device, and/or saved in the MMDE in the user computer device or any repository accessed by the computing device. To process the MMDE regardless of its source, the MMDE is displayed on the viewer's computing device. In an embodiment, the MMDE may include an advertised content, such as a banner.

In S910, at least a first image of the viewer's pupil is captured by a sensor installed or accessed by a computing device of the viewer (e.g., sensor 722) before the user views the MMDE. In S915, the MMDE is displayed on the viewer's computing device. In S920, a second image of the viewer's pupil is captured by the sensor while the viewer views the MMDE. It should be noted that either or both of the first image and second image may be a picture of the viewer's face. In such a case, a signature is only generated for one or both of the pupils. It should be noted that a pupil dilation can be determined based on a signature generated for one pupil. Using the first and second images the pupillary response is determined.

Specifically, in S925, it is checked whether a pupil dilation has occurred from the first image to second image of the pupil. That is, if a viewer's pupil is dilated in response to the viewing the MMDE. In an embodiment, S925 may include generating for the each of the first and second image of the viewer's pupil a signature. The signatures are compared to each other to check if they substantially match. If the signatures do not substantially match, then a pupil dilation may have occurred. Another check may be performed to compare the second signature to a concept structure that represents a pupil dilation to confirm a winding of the pupil. A dilated pupil lets more light into the eye and would indicate interest in the subject of attention, i.e., the displayed MMDE.

If S925 results in a positive answer, execution continues with S930; otherwise, execution continues with S980. In S930, the DCC system (e.g., system 740) is queried to find a match between at least one concept structure (CS) and the at least second image or portion thereof showing the viewer's pupil. In S935, it is checked if such a match is found, and if so execution continues with S945; otherwise, execution continues with S940. In S940, if a match was not found, the at least second image of the user's pupil is input to the DCC system 740 to create a new concept structure as discussed above and execution continues with S980. In S945, a set of metadata of the matched concept structure is returned.

In S950, the set of returned metadata is analyzed to determine the user's attention. As noted above, the metadata provides textual representation of the contents of the concept structure, thus the analysis of the textual representation also determines if at least the user's attention with respect to the input MMDE was positive (like), negative (dislike), or natural. As an example, pupil dilation may indicate that a user's autonomic nervous system sympathetic branch is stimulated and therefore the user is under stress. Therefore, the user's attention is determined as negative. In S955, the determined user's attention is associated with the input MMDE and such association is saved optionally together with the supplemental information in the database.

In an embodiment, the attention can be correlated with the input MMDE to determine the preferences of the viewer to the displayed content. For example, if the pupillary response is positive and the input MMDE is a Superman carton, then the correlation would result that the viewer likes comics in general, in particular Superman comics.

To this end, in S960, it is checked whether the input MMDE matches one or more concept structures. If such a match is found, execution continues with S970, where a set of metadata of the matched concept structure is returned. If a match was not found, execution continues with S965 where the input MMDE is provided to the DCC system to create a new concept structure as discussed above and execution continues with S980.

In S975, the metadata returned with respect to the input MMDE is correlated with the metadata returned with respect to the at least second image of the user's pupil and/or the determined attention. As noted above, the correlation outcome provides a general idea about the preferences of the user. The correlation outcome may be saved, in a database, with an identifier identifying the user (e.g., a user name) and/or an identifier identifying the computing device (e.g., an IP address). In S980, it is checked whether there are additional requests and if so, execution continues with S910, otherwise, execution terminates.

The method described with reference to FIGS. 8 and 9 can be performed in part by a server (e.g. the server 730) communicatively connected to the computing device (e.g., device 720) or by the computing device. The computing device is typically operated by a user.

The embodiments disclosed herein may be implemented as hardware, firmware, software, or any combination thereof. Moreover, the software is preferably implemented as an application program tangibly embodied on a program storage unit or non-transitory computer readable medium consisting of parts, or of certain devices and/or a combination of devices. The application program may be uploaded to, and executed by, a machine comprising any suitable architecture. Preferably, the machine is implemented on a computer platform having hardware such as one or more central processing units ("CPUs"), a memory, and input/output interfaces. The computer platform may also include an operating system and microinstruction code. The various processes and functions described herein may be either part of the microinstruction code or part of the application program, or any combination thereof, which may be executed by a CPU, whether or not such computer or processor is explicitly shown. In addition, various other peripheral units may be connected to the computer platform such as an additional data storage unit and a printing unit. Furthermore, a non-transitory computer readable medium is any computer readable medium except for a transitory propagating signal.

All examples and conditional language recited herein are intended for pedagogical purposes to aid the reader in understanding the several embodiments and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions. Moreover, all statements herein reciting principles, aspects, and embodiments of the disclosure, as well as specific examples thereof, are intended to encompass both structural and functional equivalents thereof. Additionally, it is intended that such equivalents include both currently known equivalents as well as equivalents developed in the future, i.e., any elements developed that perform the same function, regardless of structure.

What we claim is:

1. A method for determining a pupillary response to a multimedia data element (MMDE) viewed through a user computing device, comprising:

receiving a first image of a viewer's pupil captured prior to display of the MMDE over the user computing device;

receiving a second image of a viewer's pupil captured after the display of the MMDE over the user computing device;

determining, using the first image and the second image, if the viewer's pupil has been dilated;

when identifying of a pupil dilation, querying a deep-content-classification (DCC) system to find a match between at least one concept structure and the at least second image of the user's pupil;

upon identification of at least one matching concept, receiving a first set of metadata related to the at least one matching concept structure;

determining the viewer's attention to the displayed MMDE respective of the first set of metadata; and

associating the at least one MMDE with the determined user attention.

2. The method of claim **1**, further comprises:

determining preferences of the viewer with respect to the displayed content.

3. The method of claim **1**, wherein determining the preferences of the viewer further comprises:

querying the DCC system to find at least one concept structure matching the MMDE;

receiving a second set of metadata related to the at least one matching concept structure of the MMDE; and

correlating the second set of metadata returned respective of the at least one MMDE with at least one of the determined user attention and the first set of metadata.

4. The method of claim **3**, wherein each of the first and second set of metadata is a textual representation of multimedia content associated with a respective matching concept structure.

5. The method of claim **1**, wherein determining using the first image and the second image if the viewer's pupil has been dilated further comprises:

generating a first signature for the first image;

generating a second signature for the second image;

comparing the first signature to the second signature to determine if the first signature and second signature are substantially matched; and

when the first signature and second signature are substantially matched, determining a pupil dilation.

6. The method of claim **5**, further comprising:

comparing the second signature to a signature of a concept structure representing a pupil dilation to confirm a winding of pupil.

7. The method of claim **1**, wherein the MMDE is at least one of: an image, graphics, a video stream, a video clip, an audio stream, an audio clip, a video frame, a photograph, images of signals, medical signals, geophysical signals, subsonic signals, supersonic signals, electromagnetic signals, and infrared signals.

8. The method of claim **1**, wherein the DCC system comprises:

an attention processor (AP) for generating a plurality of items from the received sensory signal and determining which of the generated items are of interest for signature generation;

a signature generator (SG) for generating at least one signature responsive to at least one item of interest of the sensory signal; and

a concept generator (CG) for matching between the at least one signature generated responsive to at least one item of interest of the sensory signal and a plurality of signature reduced clusters associated with a plurality of cluster structures to identify at least the first set of metadata.

9. The method of claim **1**, wherein a concept structure is a signature reduced cluster of signatures describing multimedia elements.

10. A non-transitory computer readable medium having stored thereon instructions for causing one or more processing units to execute the method according to claim **1**.

11. A system for determining pupillary response to a multimedia data element (MMDE) viewed through a user computing device, comprising:

a processor; and

a memory connected to the processor, the memory contains instructions that when executed by the processor, the system is configured to:

receive a first image of a viewer's pupil captured prior to display of the MMDE over the user computing device;

receive a second image of a viewer's pupil captured after the display of the MMDE over the user computing device;

determine, using the first image and the second image, if the viewer's pupil has been dilated;

when identifying of a pupil dilation, query a deep-content-classification (DCC) system to find a match between at least one concept structure and the at least second image of the user's pupil;

upon identification of at least one matching concept, receive a first set of metadata related to the at least one matching concept structure;

determine the viewer's attention to the displayed MMDE respective of the first set of metadata; and

associate the at least one MMDE with the determined user attention.

12. The system of claim **11**, further configured to:

determine preferences of the viewer with respect to the displayed content.

13. The system of claim **11**, wherein when determining the preferences of the viewer the system is further configured to:

query the DCC system to find at least one concept structure matching the MMDE;

receive a second set of metadata related to the at least one matching concept structure of the MMDE; and

correlate the second set of metadata returned respective of the at least one MMDE with at least one of the determined user attention and the first set of metadata.

14. The system of claim **13**, wherein each of the first and second set of metadata is a textual representation of multimedia content associated with a respective matching concept structure.

15. The system of claim **11**, wherein when determining using the first image and the second image if the viewer's pupil has been dilated the system is further configured to:

generate a first signature for the first image;

generate a second signature for the second image;

compare the first signature to the second signature to determine if the first signature and second signature are substantially matched; and

when the first signature and second signature are substantially matched, determine a pupil dilation.

16. The system of claim **15**, further comprising:

compare the second signature to a signature of a concept structure representing a pupil dilation to confirm a winding of pupil.

17. The system of claim **11**, wherein the MMDE is at least one of: an image, graphics, a video stream, a video clip, an audio stream, an audio clip, a video frame, a photograph, images of signals, medical signals, geophysical signals, subsonic signals, supersonic signals, electromagnetic signals, and infrared signals.

18. The system of claim **11**, wherein the DCC system comprises:

an attention processor (AP) for generating a plurality of items from the received sensory signal and determining which of the generated items are of interest for signature generation;

a signature generator (SG) for generating at least one signature responsive to at least one item of interest of the sensory signal; and

a concept generator (CG) for matching between the at least one signature generated responsive to at least one item of interest of the sensory signal and a plurality of signature reduced clusters associated with a plurality of cluster structures to identify at least the first set of metadata.

19. The system of claim **11**, wherein a concept structure is a signature reduced cluster of signatures describing multimedia elements.

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